END-OF-LIFE OF GYPSUM PLASTERBOARD: EUROPEAN CASE STUDIES ANALYSIS

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ABSTRACT

Construction and Demolition (C&D) waste recycling is increasingly gaining stakeholders' attention as an strategy for contributing to sustainable construction. Although a multitude of materials are part of C&D waste, the recycling of certain fractions (i.e. metal or concrete) have a longer-established background, compared with others such as gypsum waste which is still commonly sent to landfill. Efforts are being made in order to promote gypsum recycling practices all over Europe, and the processing of gypsum waste is currently possible, becoming a reality in different regions of Belgium, Finland, France, Denmark, Sweden, the Netherlands and the United Kingdom, in which different recycling systems are now operating.

This study investigates the plasterboard waste end-of-life through a set of comparative case studies in France, Germany and the United Kingdom. The research has been developed in the framework of the Life+ GtoG project: From Production to Recycling, a Circular Economy for the European Gypsum Industry with the Demolition and Recycling Industry.

Results provide evidence of best practices through deconstruction, recycling and reincorporation operations. The operational environment of the GtoG project aims achieving a circular economy for the operators of the value chain.

Keywords: Gypsum waste, End-of-Life, recycling, circular economy

INTRODUCTION

In most European countries, gypsum waste is commonly sent to landfill. However, this material is fully recyclable [1], and gypsum recycling systems are already operating in Belgium, Denmark, Finland, France, the Netherlands, the United Kingdom and Sweden [2].

The European Life+ GtoG Project ENV/BE/001039 "From Production to Recycling, a Circular Economy for the European Gypsum Industry with the Demolition and Recycling Industry" works for fostering the recycled gypsum market, by promoting deconstruction practices, standardized quality criteria and quantifying the environmental impact of the recycling and the landfilling route. The consortium is composed by 17 European partners, including gypsum recyclers, plasterboard manufacturers, deconstruction, consultancy companies and research institutions, being the coordinator

of the project Eurogypsum, the European federation of national associations of gypsum pro

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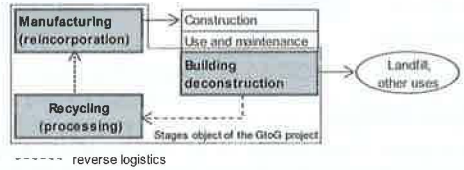

Fig.1. EoL of gypsum products scheme. The common stages of closed-loop gypsum recycling, object of the GtoG project, are highlighted in grey.

This study analyses the best practices applied during deconstruction, recycling and reincorporation operations, in three case studies located in France, Germany and the UK. In relation to the implementation of the different practices, traceability, quality of the gypsum waste and the resulting recycled gypsum reincorporation rate are identified as crucial indicators.

METHODOLOGY

This paper presents the EoL of gypsum plasterboard, from its dismantling during building deconstruction to the reincorporation of recycled gypsum into the manufacturing process.

A monitoring protocol has been developed for data collection. This protocol encompasses technical, economic, social and environmental parameters, which are combined, resulting into a total of 34 performance indicators. For the study, only the most relevant parameters related to gypsum waste and recycled gypsum have been chosen (Table 1). Considering these selected parameters, 7 best practice indicators have been formulated. A spreadsheet has been used for the data collection process. Additionally, interviews were conducted and site observations made.

Table 1. Selected quantitative and qualitative parameters and their relation with the best practice indicators proposed

Parameters	Best practice indicators						
	T_{GW}	Q_{GW} (m)	Q_{GW} (i)	T_{RG}	Q_{RG} (m)	Q_{RG} (i)	RG
GW generated on-site and sent - plasterboard (t)	X						
GW generated on-site and sent - blocks (t)	X						
GW received in recycling facility (t)	X	X	X				
GW with moisture content (t)		X					
Impurities (e.g. plastic, metal, wood) (t)			X				
RG obtained and sent (t)				X			
RG received in manufacturing facility (t)				X			X
Technical parameters					X	X	
Pre-consumer RG reincorporated (t)							X
Post-consumer RG reincorporated (t)							X
Total plasterboard produced (t)							X

T_{GW} = gypsum waste traceability; Q_{GW}(m) = gypsum waste quality (moisture); Q_{GW}(i) = gypsum waste quality (impurities); T_{RG} = recycled gypsum traceability; Q_{RG}(m) = recycled gypsum quality (moisture); Q_{RG}(i) = recycled gypsum quality (impurities); RG = recycled gypsum content

Table 2 shows the particular data related to the three different case studies.

Table 2. Case studies general data

General data	I	II	III
Pilot project deconstruction			
Bulding location	London (UK)	Graben (DE)	Levallois Perret (FR)
Period of works	July-Dec 2014	Feb-March 2014	Jan-April 2014
Type of work	Renovation	Renovation	Renovation
Floor area of the worksile (m^2)	23,784	3,450	31,992
Number of floors	12	1	9
Use	Tertiary	Tertiary	Tertiary
Year of construction	-	1965	1968
Last year of refurbishment	1980	-	2005 - 2015
Deconstruction technique	Manual	Manual	Manual
Type of gypsum waste	Plasterboard Partition	Plasterboard Ceiling, partition	Plasterboard Double partition
Type of plasterboard	12mm	-	BA13
Type of frame	Metal	Metal and wood	Metal
Deconstruction-recycling distance (km)	199.00	150.00*	86.00
Pilot project recycling			
Usual average output from recycling equipment	Gypsum (94%) Paper (6%) Metal (<1%)	Gypsum (>90%) Paper (<10%) Metal (<1%)	unknown
Pilot project reincorporation			
Recycling-reincorporation distance (km)	6.60	5.00*	0.00
Usual RG reincorporated source	production and C&D waste	production waste	production and C&D waste
Usual RG reincorporation rate	around 15%	up to 5%	between 10 - 15%

*Assumption for Germany, where there is no gypsum recycler. Average distance travelled from DA1 report, GtoG project

RESULTS AND DISCUSSION

All gypsum waste generated corresponds to recyclable plasterboard. Table 2 shows the results of the best practice indicators under study.

Table 5. Recycled gypsum quality criteria: technical parameters, results and the current proposed guidelines.

Technical parameters	Test method	First approach guidelines	Samples			
			RG-04	RG-05	RG-11	RG-12
Particle size	Granulometry	under discussion				
Free moisture (% w/w)	VGB serial number 1	< 10	1.920	0.270	4.140	4.500
Purity - Content of calcium sulphate dihydrate (% w/w)	VGB serial number 2.3	> 80*	79.830	82.970	83.060	89.260
Total organic carbon TOC - Content of residual paper/fibres (% w/w)	Gigt 3.1.3.2 DepV DIN EN 13137	< 1.5	0.630	0.820	0.780	0.300
Magnesium salts, water soluble, MgO (% w/w)	VGB serial number 8.1.2	< 0.1	0.038	0.013	0.019	0.009
Sodium salts, water soluble Na_2O (% w/w)	VGB serial number 8.2.2	< 0.06	0.026	0.023	0.028	0.021
Potassium salts, water soluble K_2O (% w/w)	VGB serial number 8.3.2	< 0.05	0.021	0.024	0.020	0.036
Soluble Chloride Cl (% w/w)	VGB serial number 8,8,3	< 0.02	0.009	0.009	0.019	0.007
Ph	VGB serial number 4	7 - 9	8.910	8.820	8.430	8.340

Purity of the recycled gypsum, free moisture, soluble chloride salts and paper content are of major importance according to the GtoG partners [4]. If there were high values of salt, this could impact on the paper binding.

The samples RG-04 and RG-05 extracted from the same case study, in average, comply with the defined quality criteria. However, if there were only one sample, RG-04, instead two of them, the purity of the recycled gypsum (highlighted in grey) would not satisfy the present-day guidelines agreed.

The GtoG project aims to reincorporate up to 30% of recycled gypsum in plasterboard manufacturing plants. Whereas the business as usual in these plants is approximately 10%, a reincorporation rate of around 20% is been reached in these three cases, which demonstrates the technical feasibility of producing plasterboards with percentage increase of recycled content.

CONCLUSION

The study analyses best practices applied during deconstruction, recycling and reincorporation operations, in three case studies located in France, Germany and the UK. In relation to the implementation of the different practices, traceability, quality of the gypsum waste and the resulting recycled gypsum reincorporation rate are identified as the crucial indicators. The most relevant conclusions are outlined below:

- Relevant parameters related to gypsum waste and recycled gypsum have been used for formulating 7 best practices indicators.
- Deviation in waste traceability and gypsum waste remains below 3% in any case.

- Gypsum waste quality can be ensured on-site if covered skips for storing the gypsum waste are used, different points of storage are avoided and a worker to follow up the waste management activities is appointed.
- When the material arrives at the recycling facility it is visually examined to ensure the compliance with the Waste Acceptance Criteria (WAC), which generally limits the free moisture and impurities content of the gypsum load.
- The quality of the recycled gypsum is measured against quality criteria parameters, formed by technical and toxicological parameters. Although diverse quality criteria currently exist, in the framework of the GtoG project, guidance values for these criteria are being developed.
- The recycled gypsum content in plasterboard production has reached an average rate of 20%, which doubles the present-day reincorporation rate in the three manufacturing plants under study.
- In one case study, recycled gypsum from C&D waste has been successfully included as a new recycled gypsum reincorporation source by an increment three times higher than with conventional sources.
- Results evidence the feasibility of achieving a circular economy for the operators of the plasterboard value chain.

ACKNOWLEDGEMENTS

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